STRATEGY RESEARCH PROJECT

THE NITZE CRITERIA AND THE BUSH MISSILE DEFENSE ARCHITECTURE

BY

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ABSTRACT

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The July 1998 Rumsfeld report on ballistic missile threats to the United States predicts that rogue nations could have the ability to strike the continental United States with ballistic missiles carrying biological or nuclear warheads within five years of a decision to acquire such a capability. In response to these growing potential threats, the Bush Administration intends to pursue deployment of a missile defense capability for protection of the 50 states.

The last major effort to deploy a missile defense system to protect the United States began under President Reagan and was called the Strategic Defense Initiative (SDI). Prior to a deployment decision of SDI, Paul Nitze, President Reagan's chief arms control advisor, proposed that the system satisfy criteria addressing military utility, survivability, and cost effectiveness. After years of research and development, Congress decided to cut the program's funding based upon criteria similar to Nitze's.

Given the controversy surrounding the planned deployment of the Bush Administration's missile defense system, this paper examines the applicability of the Nitze criteria to today's missile defense debate and determines if the criteria supports deployment of the proposed missile defense architecture.

TABLE OF CONTENTS

LIST OF TABLES

THE NITZE CRITERIA AND THE BUSH MISSILE DEFENSE ARCHITECTURE

The attack on 11 September 2001 highlighted the vulnerability of the United States and its Allies to terrorist and adversarial forces. While this attack as well as the previous attacks on Khobar Towers, the US Embassies in Africa, and the USS Cole used conventional weaponry, some states with anti-US sentiments have or are developing ballistic missiles capable of delivering weapons of mass destruction. The July 1998 Rumsfeld report on ballistic missile threats to the United States predicted that North Korea, Iran, and Iraq could have the ability to strike the continental United States with ballistic missiles carrying biological or nuclear warheads within five years of a decision to acquire such a capability. In response to these potential threats, the Bush Administration intends to pursue deployment of a missile defense capability for protection of the 50 states.

President George W. Bush's Administration is not the first to wrestle with the multiple issues surrounding the deployment of a national missile defense system. Not surprisingly, many of the arguments, from treaty implications and arms control races, to technical feasibility and cost, remain virtually unchanged since President Ronald Reagan first announced the start of the Strategic Defense Initiative (SDI) in the 1980s. To better grapple with the feasibility of deploying the missile defense initiative, Paul Nitze, President Reagan's chief arms control advisor, proposed a 3 part decision criteria focused on the system's military utility, survivability, and cost effectiveness. Ultimately the Administration invested billions of dollars into the research and development of SDI before Congress eliminated the program's funding. Using criteria very similar to Nitze's, Congress determined that the space-based concept was not technologically feasible, adequately survivable, or cost effective.

Given the controversy surrounding the planned deployment of the Bush Administration's concept for missile defense, this paper proposes an examination of the applicability of the Nitze criteria, used in the middle to late 1980s, to today's missile defense debate. This analysis makes no attempt to address the important political issues that essentially ask whether it is wise to deploy such a system. Critics of deployment note the likelihood of formation of a countervailing coalition and the risk of damaging relations with key allies. Rather this analysis focuses more on what will be the output of the previously accepted algorithm, given the state of the technological readiness of currently proposed concepts. Specifically, this paper will examine the applicability of the Reagan deployment criteria to today's missile defense controversy, and determine whether these factors would support the Bush Administration's policy to field the system as rapidly as possible.

DESCRIPTION OF SDI CONCEPT

Although the United States saw a tremendous growth in computing capability, software, sensors and lasers in the 1980s, the technological superiority America once enjoyed over the Soviet Union in weapons design had significantly eroded. The Soviet Union was also deploying long range ballistic missiles in vastly greater quantities, opening what some began to call a "window of vulnerability."[1] As an alternative to a continued policy of mutually assured destruction, where the nation's security remained in a state of vulnerability, President Reagan announced plans to build a national missile defense system called SDI that would provide complete protection to the United States from nuclear attack. SDI consisted of multiple layers of defensive weaponry and orbiting battle stations to protect the 50 states from missile attack. The defenses were to be oriented on the three primary stages of ballistic missile flight: the boost phase, the post-boost/midcourse phase, and the terminal phase.[2]

The boost phase consists of the period following missile launch, "when the booster rocket motors are burning and accelerating the missile to altitude and speed."[3] Under the SDI concept, the weapons that would intercept the incoming missiles during this phase of flight consisted of chemical lasers, particle beams, and X-ray layers. Space-based lasers would be used to focus sufficient energy on the ballistic missile to destroy it in flight. Lasers on the ground might also destroy the missiles by using space-based mirrors to direct the laser energy onto the targets. Another technique planned to use particle beams to focus accelerated sub-atomic particles on the missile warhead. The particles were intended to disrupt the electronic circuits in the guidance system and, given sufficient energy, cause the on-board ordinance to detonate. Another option involved using satellites carrying X-ray lasers that would destroy the ballistic missile by detonating a thermonuclear device in the vicinity of the target. X-rays generated from the nuclear detonation are then focused into coherent beams of laser radiation to destroy the incoming missile before the satellite itself is obliterated.[4] The destruction of the missiles during the boost phase of flight was highly beneficial because missiles capable of carrying up to as many as 30 multiple independent reentry vehicles (MIRVs) would not have had the opportunity to deploy them.[5]

Should the ballistic missiles not be destroyed in the boost phase, a greater variety of lasers augmented by rail cannons, were intended to intercept the missile in the post-boost/midcourse phase of flight. The ground-based rail cannon concept destroys incoming targets by using electromagnetic propulsion to launch metal slugs at extremely high velocities at the ballistic missiles. The rail cannon concept was promising because the anticipated exit

velocity of the metal projectile provided new ground-based alternatives to rocket propulsion for missile intercepts at speeds in excess of 5 km/second.

Reentry vehicles surviving the first two phases of defense will have now descended to an altitude of approximately 150 km and would have to be destroyed in the terminal phase. The ground-based terminal defense employs high-energy lasers, nuclear tipped interceptors, and conventional interceptors. The conventional interceptors achieved a warhead kill through kinetic energy alone, or simply putting metal on metal with tremendous intercept energy. Of the multiple concepts discussed above, the technology used in the hit to kill approach reached a level of maturity that allowed it to be used in today's missile defense development programs. Several of the problems that complicated the use of the other concepts will be discussed in the effectiveness portion of the deployment criteria.[6]

NITZE DEPLOYMENT CRITERIA

Understanding SDI's potential for encouraging an offensive arms race and increasing the risk of a nuclear war, President Reagan and his chief arms control advisor, Paul Nitze, came up with criteria to establish the viability of SDI prior to a deployment decision. The guidelines, soon to become known as the "Nitze Criteria" were that the system must be:

- Militarily effective. The effectiveness is described in terms of the system's defensive capability to counter offensive missiles.
- Adequately survivable. The largely space-based system must not be easily neutralized or destroyed by the adversary.
- Cost effective at the margin. The costs to deploy, operate and sustain the system should not be prohibitive.[7] Congress would later measure this cost against effort required by the Soviet Union to overwhelm the system with offensive weapons.

CONGRESSIONAL DECISION TO CUT SDI FUNDING

In 1991, Congress decided to cut the funding for the space-based alternative due to system cost effectiveness and survivability issues. The technology described in the SDI concept section above lacked the maturity to support funding to proceed with a deployment decision. In a case study analyzing the technical feasibility of SDI, Brendan Kitts of Brandeis University in MA, pointed out a number of critical issues that ultimately prevented the system from ever reaching the point of demonstrating its military effectiveness.

- Chemical lasers.

- Insufficient available laser power—25MW of power was required to produce the effects described by the concept yet only 0.4MW of power had been demonstrated.
- The size of the lasers needed to destroy missiles were too large to deploy into orbit cost effectively. Analysis by the Massachusetts Institute of Technology estimated that using ten space shuttles, each flying at a rate of three missions per year, would require over three thousand years to lift the fuel for the lasers into orbit.
- Reflecting laser energy off orbiting mirrors failed to account for energy lost as the beams propagated through the atmosphere.
- Mirror technology lacked the quality to reflect laser energy without absorbing heat and ultimately destroying the satellite and mirror.

- Particle beams
  - The technology was not available to steer the beams properly in the earth's magnetic field.
- X-ray lasers
  - The lasers were ineffective at altitudes below 65 miles due to atmospheric shielding effects
- Countermeasures/Discrimination Issues
  - Lasers could be easily countered by the Soviet Union
    - Fast burn boosters would reduce missile time of flight and allow lower flight trajectories (thereby reducing the laser engagement window and area of effectiveness).
    - Missiles could be hardened to reduce the laser's heating effects.
    - Missiles could be fired in salvos thereby overwhelming the system
  - Decoys, chaff, balloons, etc, travelling in close proximity of the warheads create a 'threat cloud' preventing the detection radar's ability to effectively discern the targets.[8]

Further, a Congressional task force on the SDI assigned a study group whose membership included Air Force Weapons Laboratory, Sandia National Laboratory, the U.S. Military Academy, and Bell Laboratories, to address the technical shortcomings of the initiative. In an excerpt from their 1987 conclusions the study group wrote:

> We estimate that even in the best of circumstances, a decade or more of intensive research would be required to provide the technical knowledge needed for an informed decision about the potential effectiveness and survivability of

> directed energy weapon systems. In addition, the important issues of overall system integration and effectiveness depend critically upon information that, to our knowledge, does not yet exist.[9]

The second of Nitze's criteria addressed survivability concerns with the predominately space-based system. The SDI concept did not include design features to deal with anticipated countermeasures. By the early 1980s, the Soviet Union had already tested the concept of "space mines" to destroy satellites. The Soviet Union also possessed the capability to build and deploy anti-satellite missiles (ASAT) cheaply. The missile defense system's vulnerability to unsophisticated countermeasures was a factor in Congress's analysis of the system's cost effectiveness.

The Congressional Budget Office (CBO) provided an independent estimate of the cost required to deploy the missile defense system. The CBO analysis estimated that it would cost more than $450 billion to deploy SDI over a ten year period[10]. Further, President George H. Bush reduced the scope of the system's mission from complete protection of the 50 states, to protection of the land-based nuclear force and key command centers. Under what was now to become a phased deployment of the system, the purpose of first phase was to reduce Soviet Union's confidence in their ICBMs and add a degree of complexity to their attack plans.

Based upon this restated purpose, the Congressional task force attempted to determine the cost effectiveness of the defense system based upon the balance between what the United States was paying to deploy the system versus what it would cost the Soviet Union to counter the initiative. At a cost of nearly $30,000/lb to lift objects into low earth orbit, the cost to build and deploy each SDI satellite was estimated at nearly $100M. If the Soviet Union built an inexpensive ground-based interceptor, something completely within their capabilities, their costs of the ASAT missile would be smaller than the SDI satellite cost by at least a factor of ten. Estimates based upon Extended Range Interceptor development determined that the Soviet Union could have likely built a missile costing only a few million dollars vice $100M.

The Soviet Union could also build ICBMs cheaper than what it would cost the United States to deploy SDI. The CIA estimated that the Soviet Union could build an ICBM for less than $100M and that their force numbered as many as 1800 missiles with 14,000 warheads. A Congressionally directed study conducted by Lawrence Livermore Labs concluded that SDI could intercept 15-20% of the Soviet Union's ICBM force, or approximately 300 missiles. The cost to build the 300 missiles would have been $30B, and therefore, in order for SDI to be cost effective, it would have needed to cost less than $30B. The Administration estimates for Phase I of the deployment were approximately $50B.

Thus given the costs to the Soviet Union for either building ICBMs or countering the system with ASAT or other means, Congress determined that the development and deployment expense was not cost effective for the United States.[11] This combined with the lack of demonstrated technological maturity/military utility, and survivability, persuaded Congress to cancel the funding for the space-based portion of the missile defense system in 1991.[12]

PLANNED MISSILE DEFENSE ARCHITECTURE

GROUND-BASED MIDCOURSE SEGMENT

The ground-based elements of missile defense continued development under President George H. Bush, as well as under President William J. Clinton. Overall missile defense priorities had now, however, shifted to the protection of deployed theater forces and assets. As a result, national missile defense efforts proceeded slowly as a technology readiness program until 1996. Amid intelligence estimates describing increasing threats to the homeland from rogue regions, and pressure from the Republican dominated Congress, President Clinton announced a 3+3 program for the development and deployment of a national defense system.[13] A 1998 Rumsfeld report further highlighted the vulnerability of the United States to ballistic missile attack and spawned the passage of the National Missile Defense Act of 1999.

In August 1999, President Clinton formally defined what he described as "the fastest, most affordable, and most technologically mature approach to fielding a [National Missile Defense] system capability."[14] The initial missile defense architecture would include: 100 ground-based interceptors and one anti-ballistic missile (ABM) radar deployed in Alaska, and five upgraded early warning radars. The system would be augmented by Defense Support Program (DSP) satellites to assist in the detection and tracking of the ballistic missiles.

Satellites would detect the launch of enemy ballistic missile(s), track the missile trajectories, and gather other critical data. After confirmation, missile track data is passed to the battle management system while ground-based radars acquire and track the missile(s). After authority is granted to engage the missiles, one or more ground-based interceptor missiles are launched to engage the target. The battle manager would continue to process radar and other sensor data to assist the interceptor missile(s) in discriminating between debris, false objects and the actual warheads. The interceptor missile(s) would use on board navigation in the final phases of flight to intercept and destroy the ballistic missile warheads above the earth's atmosphere. Destruction of the ballistic missile is accomplished without using an explosive warhead on the interceptor missile, but by directly colliding with the target missile at a high velocity.[15] This destruction mechanism or methodology is often called 'hit-to-kill' (HTK).

The Bush Administration that followed in 2001 continued development of this system architecture but also expanded the concept to include additional layers of defense. The new Administration would not allow the system engagement concept to be constrained by the limits of an anti-ballistic missile treaty that in President Bush's opinion was a relic of a past era. The President directed DoD officials to expand their research, development and testing to include sea, air and space-based systems, in order to intercept ballistic missiles throughout all the phases of their trajectories.[16] In line with this concept, the national missile defense and theater missile defense programs were renamed to better correspond with the phases of flight in which the systems destroy the target—boost, midcourse and terminal.

Here after, the ground-based national missile defense system will be referred to as the ground-based midcourse segment. The sea-based midcourse segment is the program that was formerly known as Navy Theater Wide (NTW). The former NTW program has also been characterized as a potential boost phase system because the Missile Defense Agency (MDA) and the Navy have considered replacing the missile booster to greatly enhance the range of the system. For the purposes of this discussion, however, it will be referred to as sea-based midcourse. The boost phase defense segment had initially included the Airborne and Space-Based Laser (SBL) Systems but the latter system was essentially cancelled when Congress cut $120M of $170M out of the Pentagon's FY02 request for SBL.[17] A brief description of the SBL concept is included the system architecture discussion and in the overall cost evaluation for the program.

AIRBORNE LASER (ABL): BOOST DEFENSE SEGMENT

The airborne laser concept places a high-energy chemical oxygen iodine laser (COIL) aboard a modified Boeing 747-400F aircraft to engage and destroy ballistic missiles in the boost phase of flight. The laser defeats enemy missiles by focusing the laser energy on the target long enough to weaken the missile's exterior in lieu of actually melting the skin. The speed and pressure of the travelling projectile will then complete its destruction. The aircraft will be equipped with a battle management system and several lasers for detection, range finding, target illumination, tracking and destruction of the enemy missiles near their launch areas.[18] The system is designed to perform its mission flying at altitudes greater than 40,000 ft.[19]

SPACE-BASED LASER (SBL): BOOST DEFENSE SEGMENT

The Space-Based Laser (SBL) concept is an outgrowth of 25 years of work which began under SDI. In a manner similar to that depicted in the SDI concept, a constellation of SBL satellites would provide worldwide coverage against ballistic missile threats by destroying them

with megawatt chemical lasers in the boost phase of flight. Although the SDI-based chemical laser concept had some significant flaws due to the limits of technology at the time, since then several key advancements in laser sizing and power have occurred. The following is an excerpt from the FY2000 Director of Operational Test & Evaluation annual report to Congress.

> Chemical laser weapons were first demonstrated in the mid-70s (dating back to the Mid-Infrared, Advanced Chemical Laser, also known as MIRACL). More recently, the Alpha program has demonstrated megawatt HF lasers suitable for space deployment. Concurrent progress has also been made with key optics technologies, such as large segmented mirrors developed under the Large Advanced Mirror Program and uncooled optics capable of handling high-energy laser beams.[20]

The complete system includes a target acquisition, tracking, and pointing (ATP) system; a beam controller for laser pointing and beam quality; and a beam director to focus the laser's energy on the target.

SEA-BASED MIDCOURSE SEGMENT

A sea-based midcourse system would build upon technologies in the existing Navy AEGIS Weapon System (AWS) and the Standard Missile (SM) infrastructures. The Navy is modifying its AEGIS combat system equipped ships to perform terminal missile defense functions in the combat theater of operations. The sea-based midcourse program would make further modifications to the AWS and SM systems to provide a midcourse defense capability against ballistic missiles. The engagement concept for the system begins with detection of missile launch by organic or other sensors. The missile track data is passed to AWS/SM modified platforms deployed near the ballistic missile launch areas to acquire and engage the threat missile. The sea-based midcourse system will destroy the ballistic missile by using a HTK mechanism similar to that used in the ground-based midcourse segment.[21]

STATUS OF DEVELOPMENT

HIT TO KILL (HTK)

Prior to 1984, missile end-game technologies were only sophisticated enough to bring a missile within close range of a target. At or in the vicinity of the closest point of the target, the missile would detonate its on board ordinance to destroy the target. Blast or debris from the explosion flying into the target provided a sufficient kill mechanism to destroy the target warhead. The U.S. Sentinel ABM system deployed in 1968—which has since been deactivated, and the Soviet Union 'Galosh' missile defense system—still deployed around Moscow today, employ nuclear tipped warheads to destroy incoming ballistic missiles based upon this

concept.[22] Advancements in sensors, computing and software in on-board missile technology have eliminated the need for explosive warheads in the interceptor missile based upon HTK technology. "HTK technology results in the total destruction of the [target] warhead through kinetic energy only, with no explosives aboard the KV. "[23] HTK technology has also been demonstrated through testing to provide greater lethality against chemical, biological, and nuclear warheads, as well as those warheads containing submunitions.[24]

HTK testing dates back to the mid-eighties and the Homing Overlay Experiment (HOE). HOE began the initial attempts to intercept and destroy an Intercontinental Ballistic Missile using a nonnuclear warhead.[25] This type of kill mechanism began to receive greater attention in the mid-nineties as part of the Army and Navy Missile Defense development programs. These programs went through learning curves reminiscent of the Corona satellite reconnaissance program, and the Thor, Atlas and Vanguard missile program developments. The combined initial success rate for these programs was 31 failures out of 38 attempts.[26] The Theater High Altitude Area Defense (THAAD) program was the first of four systems attempting to mature the technology under a success-oriented program schedule and continual pressure to field a contingency prototype system. While the program suffered under the schedule pressure, failing to intercept a surrogate ballistic missile on six successive attempts, the failures were primarily associated with quality issues and not HTK technology. After reestablishing discipline and rigor in the program with a renewed focus on quality and reliability issues, THAAD conducted two back-to-back successful intercepts.

The PATRIOT Advanced Capability (PAC) 3, Sea-based midcourse and ground-based midcourse programs, also employ HTK. The MDA worked closely with each of the programs to ensure the sharing of lessons learned and best practices across the similar development concepts. This cooperative approach resulted in a string of successes across multiple programs in the spring and autumn of 1999. During this period, PAC-3 successfully intercepted three successive targets, THAAD intercepted twice successively, and the ground-based midcourse system intercepted a ballistic missile target on its first attempt. The success rate of the technology across each of the programs in such a short time span, demonstrated not only the advancing maturity of the HTK technology, but also the potential of the overall missile defense concept.

GROUND-BASED MIDCOURSE SEGMENT FLIGHT TESTS

To date, the ground-based midcourse Joint Project Office has completed seven of twenty six planned integrated flight tests (IFT). Of the first seven missions, five were planned to

intercept surrogate targets. IFT-3 was the program's first attempt to destroy a ballistic missile in flight and by all accounts, the 2 October 1999 mission was successful. After deploying from the payload vehicle (PLV), the kill vehicle (KV) properly used its on-board sensors to locate, track, discriminate and intercept the reentry vehicle (RV). IFT-4 was the first attempt at conducting an integrated system test with each of the major system elements. The battle manager, ground-based radar, and exo-atmospheric kill vehicle (EKV) each performed all their functions nominally leading up to the final phase of flight. A failure of the EKV's cryogenic cooling system shortly after it had acquired and tracked the target, caused the EKV to miss the RV by less than 100m. IFT-5 was essentially a repeat of the IFT-4 mission, but also failed because of an anomaly in the third stage assembly of the booster that prevented the EKV from separating properly.

IFT-6 repeated the IFT-5 mission, this time however successfully destroying the target. The only anomaly in the mission was a software problem in the prototype ground-based radar approximately one minute before intercept that prevented the system's radar from confirming the intercept. IFT-7, the most recent of the tests, was also a success. An additional objective in this test included the EKV distinguishing between a large balloon acting as a decoy and the actual reentry vehicle.

Some critics of the program point out that the system is aided by a beacon from the target which was acting as a surrogate radar. The program does not plan to complete development of a mid-course radar until FY04-05, and until such time, there is a gap in radar coverage over some portion of the trajectory. Also, without this radar the system is unable to provide sufficient data on the target cluster to perform discrimination prior to passing the data to the battle manager. Software upgrades to the battle manager are in progress to allow it to develop interceptor launch plans, called task plans, but this software is not planned to be available until the summer of FY02. Program plans are to continue to use the controversial beacon in flight tests until either the upgraded battle management software becomes available or the mid-course radar is developed.[27]

AIRBORNE LASER (ABL): BOOST DEFENSE SEGMENT

After Congress cut the funding of the space-based laser concepts for SDI in 1991, the Air Force continued to assess the feasibility of mounting a megawatt laser in the nose of a large aircraft to destroy ballistic missiles. The Air Force conducted several concept and feasibility studies before ultimately awarding Team ABL, consisting of Boeing, Lockheed Martin, and TRW contractors, a $1.1B contract in November 1996 to develop and flight test an airborne laser

weapon system. [28] Two years after contract award, the ABL team had made significant steps in demonstrating the ABL concept by addressing the two major shortfalls plaguing laser technology in the SDI era: size and power. In the eighties, laser technology had not advanced to the point where it could demonstrate more than half of the power requirements, in a deployable configuration, necessary to destroy a ballistic missile. In September 1998, team ABL successfully tested a flight-weighted laser module (FLM), achieving 110% of the design output power requirements for the ABL mission.[29] The FLM prototype is one of the major building blocks for the ABL system's 747-400F-mounted high-energy laser. Other key elements such as the infrared search and track sensors for the battle manager, the beam control/fire control system (BC/FCS), and a seven ton turret assembly have met key development and testing milestones to support planned integration schedules for the aircraft.[30]

The prototype aircraft is currently in a Boeing hanger in Wichita, KS undergoing over a million man-hours in modifications which includes the integration of nearly all the major systems.[31] Following integration of the BC/FCS at LM's Sunnyvale, CA facility, the prototype will begin flight testing and calibration of the laser system in early 2002. If the development proceeds on schedule, the system will begin missile intercept testing in September 2003.

SEA-BASED MIDCOURSE SEGMENT

The sea-based midcourse segment is undergoing flight testing in the AEGIS Light Exoatmospheric Projectile (LEAP) Interceptor (ALI) program. The ALI testing began in 4QFY99 and is projected to run through the end of FY 02.[32] Employing the crawl, walk, run, test methodology, the first two flights flew against simulated targets. The second mission was unsuccessful due to a software error that ultimately precluded separation of the 2nd & 3rd stages of the missile, however, the program did successfully complete the mission in January 2001.[33] In the most recent flight test, which occurred in January 2002, the program inadvertently intercepted the target while evaluating the missile's fourth-stage kinetic warhead guidance, navigation and control system.[34] Following the completion of ALI testing, the program is scheduled to begin flight testing against threat representative targets in FY04-06. Application of the system architecture toward a sea-based national defense role, however, is still very early in the conceptual stage. In his 1 June 2001 testimony to Congress, LTG Kadish, Director, Missile Defense Agency, stated that no near term efforts were underway to upgrade existing technology to achieve sea-based boost phase intercepts.[35] In July testimony concerning the amended FY02 budget, however, he confirmed that a portion of the new funding would be applied to begin concept development and risk reduction activity for advanced capability blocks

to complement ground-based midcourse capabilities. The projected availability of a sea-based midcourse system would not occur before late this decade, and a sea-based boost phase system to serve in a national defense capacity would not be available before 2010-2012[36]

MILITARY UTILITY OF THE CURRENT MISSILE DEFENSE CONCEPT

On 1 September, 2000, President Clinton announced his decision not to proceed with the deployment of the ground based midcourse system. His administration called the ground-based midcourse system technology promising, but because the system as a whole had not been proven, he was not prepared to proceed with its deployment.[37] President Clinton's decision came two months after the IFT-5 failure and three months before he was to leave office. President Bush ran on a platform to deploy a missile defense system as soon as possible. The first of Nitze's criteria examines both the technical viability of the system and its operational effectiveness. These criteria will be explored with regard to the system maturity and demonstrated performance.

GROUND-BASED MIDCOURSE SEGMENT

Unlike its SDI predecessor, the technologies employed in the ground-based midcourse concept have demonstrated their feasibility using prototype system hardware. The HTK technology in the EKV is common across multiple missile defense programs and is in varying states of maturity depending upon the particular program phase of development. The PAC-3 missile is in the Production and Deployment phase; the THAAD missile is in the System Development and Demonstration phase; and the Standard Missile-3 of the sea-based midcourse program is in the Concept and Technology Development phase. Each of these programs have experienced a wide variety of successes and failures on the test range. In many cases, the failures were attributable to quality or reliability engineering problems that prevented the interceptor from reaching the end game where it could test HTK technology. In testifying before Congress, LTG Kadish, stated that in hit to kill missile testing where the interceptor did reach the end game, the systems successfully struck the target in 15 out of 17 attempts.[38] Further, an independent review team, led by General (ret) Welch, which was initially highly critical of the program, has since stated "that the technical capability was in hand to develop and field the limited [ground-based midcourse] system to meet the projected threat."[39]

While the HTK concept is feasible, the ground-based midcourse program is still very early in its system development, completing just 7 of 26 planned flight tests scheduled to continue through the end of FY06. The system also has not yet demonstrated the integration and maturity of all planned operational components. One of the major criticisms of the recent IFT-6

success was the use of a beacon in the reentry vehicle to compensate for the lack of a mid-range radar not planned to be built before the FY04-05 time frame. Per LTG Kadish's testimony, not only is the location of the mid-range radar yet to be determined, but options for the platform of the radar are still being studied—to include a mobile sea platform.[40] Based upon the project manager's estimate in his August 2001 Congressional testimony, battle management software responsible for developing task plans for the interceptor, will not complete the software builds necessary to conduct mission planning from target cluster tracks for another year.[41] The payload vehicle responsible for launching the EKV is a surrogate system using a two stage booster. The actual operating system will employ a three stage booster system.[42]

Perhaps the greatest criticism of the system is its unproven effectiveness under realistic conditions that would include the use of sophisticated countermeasures or multiple warheads. In fairness to the program, there are plans to address the more challenging discrimination issues and the use of countermeasures, but these objectives are not scheduled for testing until later in the program. The ground-based midcourse test methodology is modeled on the crawl, walk, run approach recommended by several experts in the community to include the Welch panel on reducing risk in ballistic missile defense programs.[43] Under this approach, there is scripting of early-on tests in order to learn as much as possible from each test event. As the system matures, the test objectives become more challenging and the missions move away from the scripted scenarios as much as range limitations will allow. Because it is cost prohibitive to flight test every conceivable scenario, system operational effectiveness evaluations are supplemented by accredited models and simulations.

GAO criticisms of the program centered around schedule and technical risk, heightened by a compressed development timeline and a limited opportunity for system testing. "The acquisition schedule is about one-half as long as the Safeguard's—the only other U.S.—based ballistic missile defense system. The NMD schedule is also shorter than schedules projected for acquisition of most other U.S. missile defense programs."[44] The greatest risk in the view of the GAO was that, under pressure from the then Clinton Administration, the program was rushing system development and that "costly redesign or modification of already produced hardware" would be required.[45] The initial Welch panel report expressed similar concerns addressing the high risk development approach, and made 18 specific recommendations to reduce program risk. In response to these recommendations, LTG Kadish added funding to the program for additional test equipment, hardware, and flight testing to reduce program risk.[46]

With the GAO issues addressed, the program is proceeding on schedule and has test plans to validate the system's capability against countermeasures. Controversy arises however

concerning the demonstrated military utility of the prototype equipment to date, amid plans to deploy the system as soon as possible. The system's true effectiveness will not be known until after integration of the system's operational components, to include the completion of SW builds, and demonstrated effectiveness in realistic environments. The latter is not likely to occur earlier than the end of FY06; at the planned completion of the flight test series. The MDA goal of a 2005 deployment would address a serious operational shortfall in BMD but would not satisfy the Nitze criteria for demonstrated military effectiveness prior to deployment.

AIRBORNE LASER (ABL): BOOST DEFENSE SEGMENT

The ABL program is in the Concept and Technology Development phase and is expected to transition into the System Development and Demonstration Phase in FY04, pending successful completion of planned FY03 testing against SCUD type missile(s). Production of the ABL system is scheduled for FY05 with plans to build seven fully operational aircraft by FY09.[47]

In an October 97 report, the General Accounting Office expressed three major concerns with the ABL concept: 1) optical turbulence the beam will encounter along its path, 2) integration of the laser system into an aircraft, and 3) development of a beam control system. The latter subsystem consist of complex software programs, moving telescopes, and sophisticated mirrors to compensate for the optical turbulence.[48] The program was subsequently restructured and an independent assessment team commissioned by Congress in 1999, determined that ABL's turbulence designs were adequate. The GAO also concurred with the findings of the assessment team, stating that the program's predictions for measuring atmospheric turbulence were valid, and that the design solutions to address turbulence were adequate.[49] Miniaturization and packaging issues for fitting the system aboard an aircraft are being addressed by the ongoing construction of a prototype ABL system in Boeing's Wichita KS facility. Raytheon successfully addressed several key issues regarding beam control in a successful March 2001 test of the Track Illuminator Laser (TILL). The TILL is a key subcomponent of the beam control/fire control system (BC/FCS) and will be integrated with the system prototype BC/FCS in early FY02. A demonstration of the full-up prototype system is scheduled for FY03.[50]

The Tactical High Energy Laser (THEL), an advanced concept technology demonstration, has done much in the way of demonstrating the feasibility of destroying a ballistic missile with a laser system. The THEL project was the result of a joint US/Israeli collaboration to develop a laser system to defeat Katyusha rockets fired by Hezbollah guerrillas from Lebanon. In June 1999, the THEL laser successfully demonstrated the ability to destroy a stationary Katyusha

rocket, and in June 2000, the system destroyed a Katyusha rocket during flight testing at White Sands Missile Range. By September 2000, THEL had shot down five additional rockets in six attempts. The flight test success has shifted current interests to designing a truck mobile system (MTHEL) that will satisfy U.S. and Israeli requirements. In June 2001, the Army awarded TRW a $5.6M contract modification to conduct a system engineering trade study of MTHEL.[51]

Based upon the ongoing Team ABL prototyping efforts and the successful THEL firings, the ABL concept appears to be feasible. Despite the successes of the THEL programs, however, a determination of the military effectiveness of an airborne laser engagement system to support a deployment decision can not occur before the program begins flight testing against ballistic missile targets in realistic environments. ABL is an entirely new system and, notwithstanding the integration challenges associated with new system design, ABL must demonstrate the effectiveness of the airborne laser concept in environments that include atmospheric turbulence, clouds and weather, and the presence of countermeasures. Assuming that the program is able to address these issues adequately with no schedule delays, a favorable production decision would not occur before FY05. A deployment decision prior to this period would not be supported by the Nitze criteria for military effectiveness.

SEA-BASED MIDCOURSE SEGMENT

The acquisition strategy for a sea-based adjunct to a national missile defense effort leverages the development of the AEGIS platform to engage short and medium range missiles. The latter program, formerly called Navy Theater Wide, is conducting testing in the Concept and Technology Development phase. In his 13 July 2001 Congressional testimony, LTG Kadish anticipated that it would be at least five years before the system would have demonstrated its effectiveness against short and medium range missiles.[52] Effectiveness against longer range missiles could be over 8-10 years away, if this concept is pursued for this mission area.

> Longer-range missiles are going to take more time, and we're going to aggressively pursue the complementary nature of that. And if we can find a very realistic approach to doing that more rapidly, we will, but my expectation right now is that it will be the end of the decade before we can actually get those systems potentially into an architecture, and maybe in the '07 and '08 time frame for tests. We'll just have to wait and see based on the results of this.[53]

LTG Kadish's 'wait and see' posture is not surprising based upon the results of the 1999 study MDA and the Navy jointly conducted to examine the feasibility of the concept of a sea-based adjunct to a national missile defense architecture. The 2000 annual report of the Director of

Operational Test & Evaluation for DoD outlines shortcomings in several key system components that would preclude the near-term viability of the AEGIS/SM-based platform.

- The AEGIS AN/SPY-1 B/D radar is not capable of supporting NMD-class engagements due to its limited detection and tracking range for strategic (long-range) ballistic missiles and their reentry vehicles. The aperture size, beam width, frequency, and bandwidth of the SPY-1 radar are unsuitable for NMD.
- To utilize the current NTW SM-3 for the NMD mission would require major propulsion upgrades. The NTW Block I SM-3 lacks the velocity required for ascent or mid-course intercepts of long-range ballistic missiles (intermediate and intercontinental ballistic missiles [IRBMs and ICBMs]).
- Several major upgrades or a full re-design are required before the NTW kinetic warhead (KW) could be used for the NMD mission. For the NMD mission, the current NTW KW lacks the required NMD endgame performance due to the limited detection range of its IR seeker and the lack of divert velocity available with the current divert and attitude control system. A second color for the IR seeker would also be required to achieve adequate endgame discrimination for advanced IRBM and ICBM threats.[54]

A deployment decision for the sea-based alternative would not be feasible before very late in the decade. Consideration prior to this time frame would not be supported by the Nitze criteria for military effectiveness.

SURVIVABILITY OF THE CURRENT MISSILE DEFENSE CONCEPT

Today, the United States has grown increasingly dependent on space to conduct everything from day to day business to global communications. Because of the civilian and military necessity for uninterrupted free access to space, and because of the devastating impact the loss of this capability would have on our economic and national security, the need to protect space-based assets has received much greater emphasis. The United States Space Command Vision for 2020 states that "USSPACECOM will protect US and allied satellite systems and be postured to conduct counterspace operations when directed to prevent enemy use of friendly, hostile, or third party systems."[55] While the details of exactly how USSPACECOM plans to protect the space media are classified, the command's vision statement clearly recognizes the need to address the vulnerability concerns associated with space-based assets.

A plan for the protection of space-based assets as described by USSPACECOM is something the SDI concept severely lacked. This problem was further exacerbated by the concept's considerable dependence on space-based platforms to defeat a ballistic missile

attack. It made little sense to spend billions of dollars deploying SDI without the ability to protect the system from attack or provide the satellites an inherent self defense capability. The Soviet Union could have defeated the system by simply disabling or destroying the highly vulnerable satellite constellation with relatively inexpensive ASAT missiles.

The multi-platform nature of President Bush's missile defense architecture in concert with the planned active protection posture of the administration has done much to improve the vulnerable aspects a national missile defense concept. Today's boost and midcourse system platforms address land, sea, air and space-based alternatives to engage and destroy ballistic missiles throughout each of the stages of its flight. The increased survivability afforded by the multi-platform approach is analogous to the land, sea and air-based triad the United States and the Soviet Union developed with their respective strategic nuclear arsenals. The triad ensured that a first strike from either nation could not completely destroy the adversary's retaliatory capability. Similarly, it would be extremely difficult for even a peer competitor of the United States to systematically neutralize each of the multiple missile defense platforms simultaneously. Thus, given the collective array of defense platforms, and the proactive plans of USSPACECOM to ensure uninterrupted free access to space, the Bush missile defense architecture would satisfy Nitze's criteria for survivability.

COST EFFECTIVENESS OF THE CURRENT MISSILE DEFENSE CONCEPT

The fiscal year 2002 budget and projected costs for the potential elements of the Bush NMD system are summarized in Table 1.

System	FY02 Budget (B)	Total Costs(B)	Availability
ABL	$.410[56]	$11[a]	2009
Sea-based Boost[b]	$.656[57]	$10	2010-2012
SBL	$.05[c][58]	$30	>2013
Ground-based Midcourse	$.847	$49[d]	2005
Total	$1.963	$100	

[a]Includes $4.6B for 20yrs O&S
[b]Funding for the program formerly called Navy Theater Wide
[c]Reduced to $50M in congressional mark ups
[d]System will cost another $1.1B annually (in FY00 dollars) to operate after 2015. SBIRS-Low is an additional $10.6B.

TABLE 1. PROJECTED SYSTEM COSTS

The Nitze criteria states that the costs of the system can not be prohibitive. In the 1991 decision to cancel the space-based funding for SDI, Congress assessed the costs of the effort relative to other spending both foreign and domestic. Recall that the projected cost for deployment of the SDI satellite system was more than $450B. In describing the current Administration's approach to defining the final architecture (& costs) of missile defense, LTG Kadish states that the configuration and the focus of resources will be determined by performance criteria. The criteria referenced in the following excerpt from his 13 July 2001 testimony concerns the purchase of a radar for the land-based system.

> So we will have confidence-building criteria as we go through this, but we will develop them based on the progress of the systems at the time. And it's not only the ground-based system; it's going to be the sea-based system and the ABL [airborne laser] and all the other things in the mix. And if one thing is doing better than the other, we're going to start looking at things differently in terms of our criteria.[59]

Spending will be prioritized to capitalize on the successful concepts. But even if the Administration pursued all of the approaches under consideration, the projected cost is still less than one quarter of the once anticipated cost of the SDI architecture. To further put the cost described in the table above in context, consider the totality of the US defense expenditures. Defense spending for FY02 is $328.7B, or approximately 3% of the gross domestic product.[60] The FY02 missile defense efforts described above account for 0.6% of the defense budget. Further, table 2 compares the development costs of some of the nation's other major weapon systems and efforts.

System	Development Costs (B)
Tomahawk Missile	$14
B2	$44.7
DDG51	$55.8
F22	$63.4
Total MD	$100
JSF	$200[61]

TABLE 2. MAJOR SYSTEM DEVELOPMENT COSTS

These comparisons in no way attempt to justify the projected costs of missile defense for the nation. The funding being discussed is certainly sizeable, but in determining the 'prohibitive' nature of the overall costs, the missile defense funding requirements must be discussed within the framework of what the nation has and is willing to pay for its strategic weapon systems. The

SDI projected funding requirements exceeded the acceptable cost threshold for even our most costly weapon systems. Based upon the comparative weapon system data above, the missile defense system components appear to fit well within the relative cost framework.

Congress however not only looked inward at relative domestic spending, but also considered what our adversary was spending to either produce more weapons to defeat the system, or would have had to pay to develop anti-satellite weapons to defeat SDI. In the studies leading up to the 1991 decision, the Soviet Union posed the only credible ballistic missile threat to the United States and the cost-effectiveness discussion was based solely upon the Soviet Union projected cost outlay. Today there are multiple nations actively developing WMD and ballistic missile capabilities, if they do not already possess them. These nations include: Iraq, Iran, North Korea, China, Syria, India, Pakistan, Libya, and Russia.[62] Table 3 shows many of their 1998 defense expenditures and the percentage of these expenditures to their respective GDPs. The collective defense spending of these nations in '98 exceeded $120B. The US by comparison in 1998 spent $266B on defense.[63] While that difference is sizeable, consider that of the $266B, only $3.7B of the U.S. defense spending was spent on missile defense.[64]

Country	FY98 Defense Expenditures in $B	% Share of GDP
China	36.7	3.5
India	13.8	4.0
Iran	5.6	5.1
Iraq	1.4	7
North Korea	2	10
Russia	53.9	13.7
Syria	2.7	16.3
Pakistan	3.9	6
Total	120[65]	

TABLE 3. DEFENSE SPENDING: NATIONS PROLIFERATING WMD

Whether these nations are attempting to gain increased WMD and ballistic missile capability, or they already possess this capability and are producing missile technology for export, significant portions of the $120B are being spent in these areas. Syria for example spent approximately $300M a year, or 11% of their defense budget, on SCUD-B/C missile acquisition after the Gulf War.[66] In May, 2000 Syria began acquisition of longer range SCUD-D missiles from North Korea.[67] While similar quantifiable data on other rogue nation internal defense spending is not available in open source literature, making a conservative assumption that they applied only half

the emphasis of Syria toward the acquisition or development of ballistic missiles, the total expenditures would still exceed $6.6B. Data from the Rumsfeld report and other intelligence sources, summarized in Table 4, indicates that increased ballistic missile capability ranks high, if not first on the funding priority list for rogue nations. If each of the nations listed spent 11% of their defense budget on the acquisition or development of these missile systems, the combined spending would exceed $13B. Granted the U.S. missile defense expenditures will increase as the program begins production and fielding of the system, but even if these costs approached $10B they would not exceed the combined efforts of the rogue nations. Thus taken in perspective with these nations, the U.S. missile defense expenditures appear to be more balanced with regard to the Nitze criteria on cost.

Country	Activity based upon Rumsfeld Report and Other Sources[68]
Iran	Iran is placing extraordinary emphasis on its ballistic missile and WMD development programs. The ballistic missile infrastructure in Iran is now more sophisticated than that of North Korea, and has benefited from broad, essential, long-term assistance from Russia and important assistance from China as well.
Iraq	Iraq continues to pursue development of SRBM systems that are not prohibited by the United Nations and may be expanding to longer-range system. Pursuit of UN-permitted missiles continues to allow Baghdad to develop technological improvements and infrastructure that could be applied to a longer-range missile program. We[CSIS] believe that development of the liquid-propellant Al-Samound SRBM probably is maturing and that a low-level operational capability could be achieved in the near term...[69]
India	India is developing a number of ballistic missiles from short range to those with ICBM-class capabilities...Technology and expertise acquired from other states, particularly from Russia, are helping India to accelerate the development and increase the sophistication of its missile systems.
Pakistan	Pakistan's ballistic missile infrastructure is now more advanced than that of North Korea. It will support development of a missile of 2,500-km range, which we believe Pakistan will seek in order to put all of India within range of Pakistani missiles.
North Korea	There is evidence that North Korea is working hard on the Taepo Dong 2 (TD-2) ballistic missile. The status of the system's development cannot be determined precisely. Nevertheless, the ballistic missile test infrastructure in North Korea is well developed.
China	China is modernizing its long range missiles and nuclear weapons in ways that will make it a more threatening power in the event of a crisis. China also poses a threat to the U.S. as a significant proliferator of ballistic missiles, weapons of mass destruction and enabling technologies.

TABLE 4. RUMSFELD REPORT & INTELLIGENCE ESTIMATES

CONCLUSIONS

Nearly twenty years have passed since President Reagan announced his administration's plans to begin work on SDI. The SDI program hoped to leverage scientific advances on the cutting edge of technology to achieve a level of nationwide protection against ballistic missile attack not realized since the beginning of the Cold War. Unfavorable Congressional review of SDI's projected cost and capabilities, coupled with the minimal effort required by the Soviet Union to defeat the system, led to its cancellation in 1991. Today the threat driving support for deployment of a missile defense system differs significantly from that of the Cold War era, but the strategic implications of such a deployment have not appreciably changed. Negative international reaction, the threat of an arms race with China, and reduced cooperation from Russia on other arms control measures, are but a few of the potential reactions to a system deployment. Swedish Foreign Minister Anna Lindh summarizes much of the negative international comments:

> The United States' plans for a national missile defense system cause serious concern. In today's globalized world, we must always take account of the global effects of our decisions. It is hard to see how a possible threat, from a few states, would best be countered by a missile shield that may or may not work, and which risks setting off a renewed arms race, with immense costs in terms of wasted resources and loss of human security.[70]

On the other hand, supporters of the system could tout compelling counter arguments in favor of the systems deployment. Rather than debating the political wisdom of deploying a missile defense system, this paper chose to leverage criteria borrowed from Paul Nitze to frame a discussion concerning the system's deployment. These criteria essentially ask if the system will be effective, survivable, and affordable.

The ground-based midcourse segment is the most mature of the system concepts, and has completed seven of 26 planned flight tests. In those tests, the system successfully destroyed the target on three of five planned intercept attempts, but without the presence of realistic countermeasures. While there are plans to demonstrate the system's effectiveness in the presence of realistic countermeasures and decoys, these more challenging tests occur much later in the flight test matrix. Further, limitations in the availability and capability of prototype system equipment necessitate the use of supplemental measures to accommodate for missing system components. As such, the true military effectiveness of the system will not be known until production representative hardware and software of the complete system is built, integrated, and tested in a realistic environment. Under current program plans, this will not occur in the ground-based segment before FY07. The sea and airborne segments of the

architecture are considerably less mature than the ground-based segment, and would not likely reach the aforementioned state of maturity before the end of the decade. Thus a deployment decision for even the most mature segment of the architecture prior to FY07 would not be consistent with Nitze's criteria for demonstrated military effectiveness.

Adequate survivability, the second of Nitze's criteria, addressed the shortfalls of a SDI concept that was primarily space-based and easily vulnerable to ASAT weapons. President George W. Bush's missile defense architecture expands the system concept to sea and airborne platforms, and provides the components de facto increased survivability in a manner analogous to the growth in architecture from solely land-based bombers, to air, sea, and ground-based missile and aircraft platforms. USSPACECOM has also established plans to ensure that the United States maintains uninterrupted free access to space. Inherent in these plans are the provisions for the protection of satellites critical to the operation of a missile defense system. Therefore, given the active protective measures planned for space-based assets, and the potential deployment of multiple system platforms, the administration's concept would satisfy the Nitze criteria for survivability.

Congress expanded upon Nitze's third criteria addressing overall affordability of a missile defense system. They found that the costs to deploy SDI were significantly greater than the efforts required by the Soviet Union to either overwhelm or destroy the system. Today, the United States no longer has a true peer competitor and the threat that was the impetus for the passage of the 1991 Missile Defense Act does not emanate from a specific nation. The multiple rogue nations involved are exporting and sharing technology to develop these weapons, while the United States is leading the effort to develop systems to defend against an attack or accidental launch.

Thus a measure of the collective efforts of a handful of these rogue nations provides something of a barometer to determine if the United States expenditures to defend against such an attack are within reason. Open source data on multiple rogue nations indicates that nations including Syria, Iran, Iraq, North Korea and China, are placing extraordinary emphasis on the research and development of ballistic missiles and WMD. While none of these nations alone constitute a peer competitor to the United States, the events of September 11th vividly demonstrate the devastation a seemingly less than formidable, yet determined enemy, can have on the country.

As the United States prosecutes its war on terrorism in Afghanistan, the military arsenal of high technology major weapon systems has allowed our armed forces to strike terrorist targets with unprecedented precision. The developmental cost of these platforms and other major

defense acquisitions provide data points useful in determining what is a reasonable expenditure for the development of our strategic systems. The collective developmental costs of the ground, sea and airborne segments in the administration's architecture are within 10% of the developmental costs of the F-22 and approximately 1/3 of the developmental costs of the Joint Strike Fighter. While none of these expenses are trivial, it would appear that the developmental costs for missile defense fits within the framework of the nation's past and present major weapon system expenditures. Thus, based upon the current spending levels, the administration's concept would meet Nitze's criteria for cost.

In summary, application of the Nitze criteria to today's missile defense debate suggests that the current spending levels appear to be within reason, relative to global WMD proliferation, and the system plans appear to be adequately survivable. Where the strategy fails to meet the criteria for deployment and begins to draw criticism, is regarding deployment decisions which precede the completion of the system's integration and demonstrated performance in realistic environments.

WORD COUNT = 9328

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